BIOFEEDBACK TRAINING AND THE HUMAN AUDITORY THRESHOLD

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Monterey, California

THESIS

BIOFEEDBACK TRAINING AND THE
HUMAN AUDITORY THRESHOLD

by

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Biofeedback Training and the

Human Auditory Threshold

by

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I. INTRODUCTION

This paper presents a research study on the relation between alpha brain wave and human auditory sensitivity threshold.

In leading to this end, there is a focus on the relation between auditory sensitivity and states of consciousness, and on the effect of biofeedback training in altering normal state of consciousness to the desired state of consciousness (alpha state).

In order to understand the goals and results presented in this paper, it is necessary to have some background information concerning each of these areas of interest.

A. AUDITORY SENSITIVITY

1. The Stimulus of Hearing

Any vibration which can be communicated to the hearing mechanism is capable of arousing hearing sensation. Stimulation occurs most commonly by sound waves, in air, but occasionally by sound waves in water or directly in the bone of the head. Sound waves in any medium consists of rapid vibratory motions of the "particles" constituting the medium. They are called waves because the motion of one particle tends to disturb the adjacent particle, which in turn disturbs the next one, so that the waves of disturbance pass through the medium. Sound waves are characterized by different physical features such as frequency, amplitude, phase, and intensity. Frequency

is defined as the number of cycles completed per unit of time. Amplitude is described as the amount of diplacement of the vibrating particles in either direction from the position of rest. Phase is the stage toward which vibrating motion has advanced from its starting point or position of rest. Intensity is described as pressure variation. These different characteristics of sound promote the limitation of human auditory mechanism in its ability to respond to acoustic energy.

2. <u>The Auditory System</u>

The auditory system consists of the receptor organs (the ears), the neural conductive mechanism and the central projection areas in the cerebral cortex of the brain. To give a complete physical and functional description of all these organs would become rather complicated. To serve the purpose of this study, however, it is necessary to know only the neural conductive mechanism, and the central projection areas in the cerebral cortex of the brain.

a. The Neural Conductive Mechanism

The sound, after propagating in the air, is received by the ears (outer, middle and inner ears) and processed by the neural conductive mechanism which is the primary conductive mechanism for the sense of hearing. This is the auditory portion of the eighth cranial (acoustic) nerve. The afferent neurons of the eighth cranial nerve make contact with the hair cells of the organ of Corti; each nerve fiber connects with one or more inner hair cells. The external hair cells, however, are innervated by multiple fibers. Located within the central core of the cochlea in the spiral ganglion

of Corti are the cell bodies of approximately 30,000 ganglion cells whose axons form the beginning of the auditory branch of the eighth cranial nerve. The fibers of the auditory nerve leave the cochlea at its base and extend about 5^{mm} to the cochlea nuclei of the medulla. These synaptic connections are made with second order neurons which proceed to other centers. Some of the axons of the second order neurons from the right and left ears remain in their respective cerebral hemispheres, but many others cross the contralateral side and make connections at the level of the pons. Third order neurons then run upward in the lateral lemniscus, terminating in the inferior colliculus of the midbrain or continuing to the medial geniculate body of the thalamus. From the medial geniculate body, the axons of the fourth order neurons form radiation fibers in each hemisphere which spread to the appropriate temporal lobe (right or left) of the cerebral cortex.

b. The Central Projection Areas

The neural connection from the cochlea structures to the temporal lobes are complex, but three major points should be stressed. First, both ears have connections to the right and left temporal lobes, thus providing neural pathways through which binaural interaction can occur. Second, in the central mechanism of hearing, in each auditory cortex, different frequencies of excitation at the cochlea are projected and localized at different cortical regions. Tone of high, middle and low frequency are separated spatially in the cortex as they are in the auditory nerve. Third, the decussation of fibers

of the auditory nerve produces a conditon in which cortical responses from the contralateral ear are stronger than those from homolateral ear.

3. <u>The Auditory Sensitivity Threshold</u>

The theory prescribed in part 1 and 2 indicates that the human auditory mechanism is limited in its ability to respond to acoustic energy. Consequently, the absolute sensitivity of the auditory mechanism is physically determined by the minimal energy needed to produce a sensation of hearing. This is referred to as the threshold of sensitivity.

In 1824, Herbart introduced the term "threshold" into psychology with his definition of "threshold of consciousness." This was specified as that "boundary which an idea appears to cross as it passes from the totally inhibited state into some degree of actual ideation."

The classical notion of threshold, as held by Fechner (1860) was that the brain in its waking states was physiologically active. In order for an incoming stimulus to be detected, it had to generate neurological excitation which is sufficiently larger than those residually present as the result of the spontaneous activity of the brain. A liminal stimulus difference was one which "lifted the sensation or sensory difference over the threshold of consciousness."

Herbart's and Fechner's notion of threshold has promoted a direct relation between sensitivity threshold and states of consciousness. The latter will be discussed in section C.

4. Mental Fatigue and Perceptual Sensitivity Performance

Welford (1965) defined mental fatigue as the impairment of some brain mechanism as a result of long continued use. One of the explanatory models of mental fatigue is the notion of local neural impairment. The traditional assumption is that some group of nerve cells concerned with the performance or with some essential link in it, become insensitive or unresponsive through continued activity. This can account for slowing of performance by assuming that some stage in the sensory-motor chain requires a stronger stimulus to operate it and that given level of stimulation can be integrated over time.

Mackworth (1950), while studying performance on an auditory vigilance task, revealed that mental fatigue reduces performance. This occurred when Mackworth studied an auditory task which required subjects to listen for two hours to a series of 1000 CPS tones of two second duration occurring about every 18 seconds. Mackworth found that in his first experiment, the percentage of signals missed at the end of first half hour was 15.7%, and at the end of second half hour 25.8%. Over the next two half-hour periods, performance showed little further deterioration (26.8% and 28.0% signals were missed). In the second experiment he reduced the length of the task to one hour, with the result that 13.0% to 15.3% signals were missed in the first half and 24.2% to 30.4% in the second. In the third experiment, he reduced the length of task still further to 30 minutes, with the restriction that subjects worked and rested for alternate 30 minute periods

over two hours. The mean incidence of signals missed over the four periods of the task were 18.1%, 20.7%, 16.5% and 18.5%. These data indicated that a rest pause of the same duration is sufficient to restore the subject efficiency to its former level.

Fraser and Samuel (1956) noted that physical fatigue exerts comparatively little effect upon vigilance performance while mental fatigue brings about considerable deterioration of performance. Mast and Heimstra (1964) compared three fatigue conditions with each other and with a control condition. In the first fatigue conditon subjects worked at mental multiplication problem for four hours before performing the driving task for four hours and were additionally required to detect brightness changes in a pair of red lights located about seven feet away at the end of the roadway. The two hour visual vigilance task involved the detection of brightness changes in a spot of light; subjects gained five cents for each signal detected and lost ten cents for each error of ommission or commission. The two kinds of errors were summed in analysis, which showed that the first fatigue condition, said to involve mental fatigue, produced a greater number of errors than either the control conditions or the other fatigue conditions, which were supposed to involve phsycial or "skill" fatigue.

B. ALTERED STATES OF CONSCIOUSNESS (ASC)

Tart (1969) defined a state of consciousness as an overall patterning of psychological functioning. A normal state of

consciousness can be considered as a resultant of living in a particular environment, both physical and psychological. The normal state of consciousness for any individual is one that has adaptive value within his particular culture and environment. An altered state of consciousness may be defined as a qualitative alteration in the overall pattern of mental functioning, such that the experimenter feels his consciousness is radically different from the normal way it functions.

Kanellakos (1968) stated that the different states of consciousness are reflected through different states of the nervous system. Krippner (1969) defined different states of consciousness as the mental states which can be subjectively recognized by an individual (or by an objective observer of the individual) as representing a difference in psychological functioning from that individual's "normal" state.

1. Production of ASC

Lindsey (1961) stated that ASC's may be produced in any setting by a wide variety of agents or maneuvers. These methods interfere with the normal intake of sensory or proprioceptive stimuli and the normal output of motor impulses or the normal flow and organization of cognitive processes. There seems to be an optimal range of exteroceptive stimulation necessary for the maintenance of normal, waking consciousness. Levels of stimulation either above or below this range appear conductive to the production of ASC's.

Hebb (1958) found that varied diversified environmental stimulation appears necessary for the maintenace of normal cognitive, perceptual, and emotional experience. When

such stimulation is lacking, mental aberrations are likely to occur. Although experimental evidence is sparse concerning the manipulation of motor, cognitive, and emotional processes, there seems to be ample clinical and anecdotal evidence to suggest that gross interference with these processes may likewise produce alteration in consciousness.

The methods of producing ASC's may be categorized as follows:

a. Reduction of Exteroceptive Stimulation and/or Motor Activity

Under this category are included mental states resulting primarily from the absolute reduction of sensory input, the change in patterning of sensory data, or constant exposure to repetitive monotonous stimulation. A drastic reduction of motor activity also may prove an important contributing factor.

Burney (1952) and Meltzer (1956) associated absolute reduction of sensory input with solitary confinement. Anderson (1942), Gibson (1953) and Slocum (1948) related the change in patterning of sensory data, or constant exposure to repetitive monotonous stimulation to the situation while at sea. Bird (1938) and Ritter (1954) associated this sensory deprived state with the situation while in the arctic. Mosley (1953) related this same sensory deprived state to the situation while in the desert and to the experience of highway hypnosis. Benett (1961) associated a drastic reduction of motor activity with the "break off" phenomena in high altitude jet pilots while Heron (1957) related this state to extreme boredom.

b. Increase of Exteroceptive Stimulation and/or Motor Activity and/or Emotion

Under this category are included excitatory mental states resulting primarily from sensory overload or bombardment. These states may or may not be accompanied by strenuous physical activity or exertion. Profound emotional arousal and mental fatigue may be major contributing factors.

Sargant (1957) related the excitory mental state resulting from sensory overload produced by grilling or "third degree" tactics and brainwashing. Labarre (1962) and Marks (1947) related the profound emotional arousal state to the hyperkinetic trance associated with emotional contagion encountered in a group or role setting. Sargant (1957) and Labarre (1962) related this same state to religious conversion and healing trance experiences during revivalistic meeting. Alteration in consciousness may also arise from inner turbulence or conflict conducive to heightened emotional arousal. Examples of these states would include fatigues, amnenas, traumatic neuroses, depersonalization and panic states.

c. Increased Alertness or Mental Involvement

Under this category are included mental states which appear to result primarily from focused or selective hyperalertness with resultant peripheral hypoalertness over a sustained period of time.

Heron (1957) found that the state which resulted in increased alertness arose from the prolonged observation of radar screen, prolonged vigilance during sentry duty and crow's watch. Ludwig (1965) noted that the hyperalert state

which resulted from mental involvement arose from the mental absorption in a task, such as reading, writing, problem solving, and total mental involvement in listening to a dynamic or charismatic speaker. Magolin and Kubie (1944) found that the same state arose even from attending to one's amplified breath sounds.

d. Decreased Alertness or Relaxation of Critical Faculties

Under this category are included mental states which appear to occur mainly as a result of what might best be described as a "passive state of mind" in which active goal-directed thinking is minimal.

Burke (1951) and Ludwig (1966) revealed that the passive state of mind may be described as mystical, transcendental or revelatory (Satori, Samadhi, cosmic consciousness). These states are attained through passive meditation or occur spontaneously during the relaxation of one's critical faculties. Kamiya (1969) notes that the "alpha state" which results from biofeedback training may be placed in this category.

e. Presence of Somatopsychological Factors

Under this category are included mental states primarily resulting from alterations in body chemistry or neurophysiology. These alterations may be deliberately induced or may result from conditions over which the individual has little or no control.

Hinkle (1961) noted that such ASCs may arise from hypoglycemia (lack of sugar in blood) either spontaneous or subsequent to fasting, hyperglycemia, dehydration, etc.. In

addition, ASCs may be induced through the administration of numerous pharmacological agents. These drugs include anesthetics, psychedelics, narcotics, sedatives and stimulants.

2. General Characteristics of ASCs

Ludwig (1966) indicated that despite the apparent differences among ASCs, there are a number of common denominators or features which allow a conceptualization of these ASCs as somewhat related phenomena as follows:

a. Alteration in Thinking

Subjective disturbances in concentration, attention, memory and judgement represent a common finding. Archaic modes of thought predominate, and reality testing seems impaired to varying degrees. The distinction between cause and effect becomes blurred, and ambivalence may be pronounced whereby incongruities or opposites may coexist without any psychological conflict. Moreover, as Rapaport (1951) and Brenman (1950) have commented, these states are associated with a decrease in reflective awareness.

b. Disturbed Time Sense

Sense of time and chronology become greatly altered. Subjective feelings of timelessness occur. Time seems to come to a standstill; time also may seem infinite or like an infinitesimal duration (Ludwig, 1969).

c. Loss of Control

The experience of "loss of control" is a complicated phenomenon. Relinquishing conscious control may arouse feelings of impotency and helplessness, or, paradoxically, may represent the gaining of greater control and power through

the loss of control. This latter experience may be found in hypnotized persons (Kubie and Margolin, 1944; Gill and Brenman, 1959). It may also be found in audiences who vicariously identify with the power and omnipotence which they attribute to the hypnotist.

d. Change in Emotional Expression

With the diminution of conscious control or inhibitions, there is often a marked change in emotional expression. Sudden and unexpected displays of a more primitive and intense emotion than shown during normal, waking consciousness may appear. Emotional extremes, from ecstacy and orgiastic equivalents, to profound fear and depression, commonly occur (Ludwig 1969).

e. Body Image Change

A wide array of distortion in body image frequently occur in ASCs. There is also a propensity for individuals to experience a profound sense of depersonalization, a schism between body and mind, feelings of derealization, or a dissolution of boundaries between self and others, the world or universe.

f. Disturbed Perception

Common to most ASCs is the presence of perceptual aberration, including hallucinations, pseudohallucinations, increased visual imagery, subjectively felt hyperacuteness of perception and illusions of every variety. In some ASCs, such as those produced by psychedelic drugs, marijuana or mystical contemplation, synesthesias may appear whereby one form of sensory experience is translated into another form.

For example, persons may report seeing or feeling sounds or being able to taste what they see.

g. Change in Meaning or Significance

Persons in ASC attach an increased meaning or significance to their subjective experience, ideas, or perceptions. At the time, it appears as though the person is undergoing an attenuated "eureka" experience during which feelings of profound insight, illumination and truth frequently occur. (Ludwig, 1966).

h. Sense of the Ineffable

Most often, because of the uniqueness of the subjective experience associated with certain ASCs, persons claim a certain ineptness, or inability, to communicate the nature or essence of the experience to someone who has not undergone a similar experience.

i. Feeling of Rejuvenation

In emerging from certain profound alteration of consciousness many persons claim to experience a new sense of hope, rejuvenation, renaissance, or rebirth (Labarre 1962, Coe, 1916).

C. ALPHA WAVE

Alpha is the name given to the wave length of one pattern of electrical activity produced by the brain. It measures eight to twelve cycles per second, according to most authorities. However, a few scientists choose to chart alpha wave from seven to thirteen cycles per second. The alpha brain wave varies in amplitude or strength in each person based upon individual differences and on past training.

Hans Berger, a German psychiatrist, is generally given credit for discovering alpha brain waves in 1929. Although alpha waves have always been produced by the brain, the discovery of this characteristic brain wave had to wait until 1929 because adequate machinery had to be developed before it was possible to detect this subtle energy. It is measured in microvolts and ranges from 20 to 150 microvolts.

1. <u>Source of Alpha</u>

Inside each person is a private universe. Fifteen billion or more cells compose the brain and, like the stars, the galaxy of brain cells is arranged in bunches and groups. These "cell galaxies" are called cortical areas of the brain. The most evident cells are those of the cerebral cortex. These retain stimuli like higher universities of knowledge, while the other cells can be compared to through stations and paths of information like a primary elementary school.

Many layers make up the brain, almost like a fresh walnut. A skin envelope surrounds it all and the skull acts as a protective shell. Under this is the inner skin of the soft membrane which covers the hardish matter of the brain. The exquisite kernel of dura matter lurks inside all this like a kernel of consciousness. The cerebral cortex, the brainstem, and the cerebellum are the three areas of the brain. Both brainstem and cerebellum are called "white matter" areas because of the white color of the axons covering them. The cerebral cortex is mostly grayish in color, from the gray appearance of the neuron bodies.

The brain is actually a pair of brains, with two independent "hemispheres" on the right and left like separate continents. Generally, one hemisphere is dominant. Women tend to have a more even balance between hemispheres than men. Paul Bakan's (1971) controversial hemisphere study offered certain characteristics for the left and right hemisphere dominance. He suggested that the left hemisphere deals with rational, objective, active, tense, verbal, abstract, euphoric, and sympathetic qualities. He states that the right hemisphere is concerned with the preverbal, spatial, emotional, passive, subjective, relaxed, and depressed qualities.

When someone is best described by one set of adjectives over another, Bakan (1971) proposed the corresponding hemisphere is probably the dominant one. According to the theory, the analytical verbal person will ponder, and glance upward and to the right in opposition to his dominant brain hemisphere, the left hemisphere. The emotional, subjective person will move his eyes upward, and to the left, as the thinks about the answer to someone's question signifying dominance of his right hemisphere. Bakan (1971) noted that people with right hemisphere dominance generally produce alpha brain waves more easily than people with left hemisphere dominance.

The base of these two hemispheres in the brain is connected with white matter, like a network of tissue bridges and girders. Each hemisphere is divided into areas scientists call lobes. Each is enveloped with supporting membrances, the three meninges. These meninges are tough fibrous membranes

made of dura matter and a softer pia matter, all protecting the brain. The areas called lobes are the frontal lobe, in front of the brain, the parietal lobe, on the top of the head, the occipital lobe, behind the parietal, about where the back of the head rounds out to its furthesr peak, and the temporal lobe connecting the occipital to the frontal lobe.

Scientists attach specific functions to the lobes of the brain. Alpha waves are most likely to occur in the occipital lobe, which is linked to visual impressions, abstract thinking and conceptualization. The frontal lobe is the reflective contemplative area. The temporal lobe, the center of word and sound formation is thought to be most prominent if someone is an auditory person or one who learns most quickly through a lecture rather than through reading a book.

2. <u>Properties of Alpha States</u>

The alpha state has been described by scientists as a state of consciousness where alpha brain waves are abundant. This state, moreover, has the following properties:

a. Electrical Properties

Alpha amplitude varies from 20 microvolts to 150 microvolts. Alpha varies from person to person and has different peaks for different people.

b. Physiological Properties

Edward Bokert (1969) noted that metabolism decreased, temperature and blood pressure dropped, respiration and heart beat was lowered, and muscle tension fell to low levels as alpha was produced in a person.

c. Psychological Properties

Kamiya (1969) pointed out that alpha state is not just a kind of relaxation, which leads to drowsiness, like lying down to rest and nap. Instead alpha is a specialized relaxation with a certain kind of focus of attention that increases awareness. Moreover high alpha producers tend to be sensitive and empathetic.

Bokert (1969) said "when people are more relaxed, they do not feel as excitedly aroused and can openly devote their full attention to everything around them."

Fehmi (1969) called the alpha state one in which there is "enhanced ability to attend, have presence, awareness or attention." This should have implications for various kinds of performance tasks which require this psychological state.

Budzinski and Stovya (1969) noted that people became more sensitive and sometimes felt vulnerable as they became aware of their own alpha brain waves. Most people described alpha as a pleasant feeling, a sensation of well-being, tranquility and relaxation.

3. Meditation and Alpha Production

a. Zen Meditation

Zen meditation means the sitting meditation which is a kind of religious exercise in Zen Buddhism. In Japan, there are two zen sects named Soto and Rinzai. Both sects regard Zazen as the most important training method of their disciplines to enlighten the minds. Zen sitting is performed

in two basic meditation forms. A full cross-legged sitting and a half cross-legged sitting. During the Zen sitting, the disciple's eyes must be opened and look downward about one meter ahead, and his hands generally join. In a quiet room, the disciple sits on a round cushion and practices the meditation for about thirty minutes. Sometimes the intensive Zen training is performed 8 to 10 times a day for about one week. This is called Sesshin in Zen Buddhism.

Hirai (1960) stated that the disciples do not engage in "normal" secular daily activities but live the religious life following a strict schedule. Many of the disciples work in the garden, in the kitchen, and in various handwork kinds of activities.

By practicing Zen meditation, it is said that man can become emancipated from the dualistic bondage of subjectivity and objectivity, of mind and body and of birth and death. And he can be free from self consciousness. It is said he can be awakened to his pure, serene and true self. In an EEG study of Zen meditation, Kamatsu and Hirai (1969) found that after Zen meditation has started, the well organized alpha waves of 40 to 50 microvolts, 11 to 12/sec. appear within 50 seconds in all the brain regions and continue for several minutes in spite of opened eyes. After 8 minutes and 20 seconds, the amplitude of alpha waves reaches to 60 - 70 microvolts predominantly in the frontal and the central regions. Initially, these alpha waves alternate with short runs of the activating pattern, but a fairly stable period of the persistent alpha waves ensues during the progress of Zen meditation.

After 27 minutes and 10 seconds, rhythmical waves of 7 - 8/ second appear for one to two seconds. And 20 seconds later rhythmical theta trains (6 - 7/seconds, 70 - 100 microvolts) begin to appear. However, this does not always occur. After the end of Zen meditation alpha waves are seen continuously and two minutes later alpha waves still persist. It seems to be the after-effect of Zen meditation.

Kamiya (1969) also invited several Zen priests, practiced in meditation to come into his laboratory to monitor their brain waves. He found that they learn to control alpha much more rapidly than most subjects and that they appeared to do so through meditation procedure. A number of studies on the physiological correlates of meditation support this observation (Kamiya, Bagachi, and Wenger (1957); Anand, Chhina and Singh (1961); Wallace (1970); Kasamatsu and Hirai (1966).

b. Yoga Meditation

(1) <u>Yoga</u>

(a) Strictly speaking, Yoga refers to a system of beliefs and practices whose goal is to attain a "union" of the individual self with Supreme Reality or the universal self. There are several systems of Yoga in this sense (DAS, 1963; Wood, 1959; Woods, 1927). Each has an ethical-religious discipline at the core and each sees the trance state of samadhi as the final step in attaining "union" with Supreme Reality. However, each system of Yoga emphasizes somewhat different processes for the attainment of samadhi and "union." For instance, the eightfold system of Raja Yoga,

taught by Patanjali includes self control (yama), religious observances (niyama), physical postures (asana), regulation of the breath (prarayama), suppression of the flow of external sense impressions (prtayahara), concentration or fixed attention on an object (dharana), meditation or contemplation of an object for a long period of time (dhyana) and, finally, a state of absorption or trance in which the person is no longer conscious of his concentration (samadhi).

(b) In its popular usage, especially current in the West, the term Yoga has come to be associated more or less exclusively with the physical postures (asana) and the regulation of breathing (pranayama). This popular usage is not found in Indian philosophy. An individual who merely practices the postures and the breathing exercises (as some do for health or therapeutic purposes), without a concomitant consecration to a spirit of discipline and to the goals of Yoga, is simply practicing a few yogic exercises. He is not practicing Yoga in the strict sense.

(2) Yogi. The term Yogi has a strict meaning. A Yogi is described as a person who has obstensibly attained the goal of Yoga, namely samadhi or a "yoking with" or "union" with Supreme Reality. Yoga aims at freedom from the "world illusion" through the achievement of samadhi.

(3) Yoga and Alpha Production. In an EEG session, Bagachi and Wenger (1957) noted that Yogic meditation represents deep relaxation of the autonomic nervous system without drowsiness or sleep and a type of cerebral activity without highly accelerated electro-physiological manifestation. In waking

alpha pattern was also seen. It ranged from 8.5 to 11 cycles per second and with strengths of 20 to 100 microvolts, sometimes one-half or one beat slower, and sometimes with good amplitude modulation and regulation. Anand, Chhina and Singh (1961) have studied the physiological correlates of Yogi meditation. Investigation by these authors indicated that the meditative exercises practiced by the Yogis they tested were accompanied by a high percentage of alpha. Generally, both alpha amplitude and percentage was quite high while the subjects were meditating.

c. Transcendental Meditation

Maharishi Mahesh Yogi is the founder of transcendental meditation. He is a metaphysician with a degree in physics from the University of Allahabad, India. As a young man, the Maharishi abandoned western science and went on a spiritual pilgrimage. He studied with a teacher called Guru Dev. He lived in a care in the Himalayas for two years and later, on an inspiration, he wandered through the forest of Southern India, as every Yogi of great spiritual ambition must.

In mid 1950's, the Maharishi relinquished his solitude. He began to teach, and his lectures remained the same. He has lectured around the world and taught thousands of people the technique of transcendental meditation.

The purpose of transcendental meditation is to help individuals expand their minds, develop their creative intelligence and make use of their full potential in studies, career, and recreation.

Transcendental meditation is a natural technique which allows the conscious mind to experience increasingly more subtle states of thought until the source of thought, the unlimited reservoir of energy and creative intelligence, is reached. This single practice is said to expand the capacity of the conscious mind, and a man moves toward full use of his potential in the field of thought and action.

The vehicle of transcending the level of conscious thought is a "mantra." A mantra is a sound taken from Sanskrit. It is given to the practitioner of TM by a trained teacher who instructs him in its use at an initiation. TM is practiced twice a day for 15 to 20 minutes, sitting in a comfortable position with the eyes closed. Unlike some other meditation, TM does not use concentration but rather "passive volition" as is used in Autogenic Feedback (Green et al, 1970) for control of the autonomic nervous system.

Maharishi (1969) emphasized that TM "is neither a matter of contemplation nor concentration. The process of concentration and contemplation each hold the mind on the conscious thinking level, whereas transcendental meditation systematically takes the mind to the source of thought, the pure field of creative intelligence."

Wallace (1970) noted that during meditation, the transcendental meditator showed changes in oxygen consumption, brain waves and skin resistance. He observed increases in alpha waves during meditation, particularly in the frontal areas of the brain. The alpha waves were more intense than when his subjects merely close their eyes. The meditators,

moreover, were deeply relaxed. In other words, they were also awake as their reactions to stimuli demonstrated. More recently, Wallace and Benson (1971) studied the physiological effects of transcendental meditation in American subjects. The subjects had been practicing meditation procedures for periods of between one month to nine years, with the majority of the subjects having had from two to three years of "training" (two 15 - 20 minute sessions per day). In these exercises, the subject sits in a comfortable position with eyes closed. The meditator then perceives a suitable sound or thought. Without attempting to concentrate specifically on this cue, he allows his mind to experience it freely. Thinking, as the practitioners themselves report, rises to a finer and more creative level in an easy and natural manner. Wallace and Benson (1971) found these meditation procedures to be associated with marked intensification of alpha waves in all subjects.

4. Relaxation and Alpha Production

Most people when generating alpha express the feeling of relaxation. Erickson (1967) and Kamiya (1969) described the good alpha subject as a person who appears interested, relaxed, and comfortable. These individuals look people in the eyes and feel comfortable in close interpersonal relationships. This description, it should be noted, is ued to define relaxed persons in the present study.

In contast to the description of Erickson (1967) and Kamiya (1969), Saul and David (1949) noted that aggressive individuals were low alpha producers. Glaser (1963) stated that,

"tension, apprehension, and anxiety lead to a decrease in alpha activity."

Thus, the above findings lead to hypothesis one: meditators and relaxed persons may produce higher amounts of alpha than non meditators.

D. BIOFEEDBACK

1. Definition

Biofeedback is a new term for a new technique. "Bio" comes from the Greek word bios, meaning life or living organism. "Feedback" is a technical term referring to giving back the effect of a process to its source.

Biofeedback occurs when people receive information concerning their internal state. The information is sent through a mechanical device, known as a feedback instrument.

The biofeedback techniques are based on the principle that a certain response is made when informational feedback is received by the organism. These reponses are adjusted, corrected, and modified as feedback is continually received until it is determined that a final goal is achieved. This new field of research has important implications for the study of altered states of consciousness.

2. Biofeedback and Alpha Training

Kamiya (1962, 1967, 1968, and 1969) was the first investigator to attempt the study of operant control of EEG alpha and associated changes in mental activities.

Kamiya (1962) was first interested in the question of whether human subjects could be trained to discriminate the

presence or absence of alpha. The subject was told that from time to time he would hear a bell ring; when he heard it, he was to make a guess as to whether he was producing or not producing alpha. As soon as he made his response, the experimenter told him if he was correct. The result indicated that after several sessions of training, most subjects had increased their discrimination accuracy well above the 50 percent chance level.

Kamiya (1967, 1968, 1969) then turned his attention to the question of whether subjects could exercise control over their alpha activity and produce this brain wave pattern on command. He constructed an automated biofeedback system which employed an electronic device that would turn on a sine-wave in the subject's room when the alpha wave was present. The tone would cease as soon as the alpha wave would disappear. Kamiya then conducted a number of experiments where he would tell the subject to turn the tone either on or off. In the first phase of this research, Kamiya only trained people to suppress their alpha, finding that six of his seven subjects were able to perform this task (Kamiya, 1969). In another experiment employing three conditions (an alpha generation condition, alpha suppression and basal level rest period), Kamiya (1969) found a marked difference between generation and suppression. The basal level, however, was higher than the generation condition. These data, however, do not refute the fact that autonomic learning has occurred, as it is quite likely that basal level alpha can change (Crider, Schwartz

and Shnidman, 1959). It should also be noted that alpha during the generation trials was of a higher amplitude than the alpha present in the base line periods.

Bundzen (1965); Dewan (1966), Mulholland (1967), Hart (1968) and others have also demonstrated that subjects can learn to control the appearance of their alpha wave in the EEG record through an auditory feedback loop keyed to the alpha which lets the subject know when he is producing a designed pattern. Dewan (1966) was able to learn to control the presence or absence in his own EEG record so well that he could use his EEG to send messages to a computer in Morse code. Hart (1968) has shown that subjects given a total of two minutes immediate feedback for presence of alpha brain wave, learn faster than those who just receive immediate feed back. Mulholland (1967) hypothesized that alpha wave was related to position of the eye. He thought alpha increased when the eyes are moved to an extreme side or up position. However, a study of 16 subjects by Fenwick (1966) found that alpha was not significantly related to the eye position suggested by Mulholland (1967), although a few of the subjects did show the hypothesized effect. Furthermore, Kamiya (1967) stated that his subjects could learn to control alpha with their eyes in the up or down position. Thus, although the Mulholland effect has not been ruled out for all subjects, it does not seem to be widespread. Mulholland (1967) recognized that the hypothesized relationship was not characteristic of all subjects. The above research leads to hypothesis two:

subjects given biofeedback training produce more alpha than subjects with no biofeedback training.

3. Biofeedback, Altered States of Consciousness, Alpha, and Performance

Krippner (1969) stated that the implication for biofeedback techniques lies in the creative process. There exists annecdotal and clinical evidence suggesting that altered states of consciousness may facilitate the creative act. By enabling individuals to enter non-ordinary states of consciousness, creative ability may be enhanced. Murphy (1958) delineated several stages of creative process. He designated the first stage as "immersion." The individual sensitivity contemplates the surrounding environment in preparation for a synthesis and consolidation of experiences which eventually leads to the act itself. Particularly in the first stage of immersion and contemplation, biofeedback techniques may prove to be quite useful. The alpha state has often been described as a passive, contemplating type of experience. Sometimes the subject might even experience a fusion of himself with the surrounding environment. If a person can be taught to voluntarily attain this type of state, his creative ability might possibly be facilitated.

Moreover, there have been several studies on paranormal phenomena. Can biofeedback techniques be used to train such "psi" abilities as "extrasensory" perception (ESP)? In the studies of Ullman and Krippner (1970); Krippner and Davidson (1970); Honorton (1969); Cavanna (1970), ESP appears

to be facilitated in altered states of consciousness. Possibly, when an individual shifts into a different mental state, he becomes temporarily "suspended" from cultural habits and societal conditioning and is more amenable to subtle forms of communication such as the "extra-sensory." Thus by training a person to shift voluntarily into different states, these "extra-sensory" processes may be enhanced.

The findings to date demonstrate the complexity of this area. There have been several studies on the relationship between alpha and ESP (Davidson and Krippner, 1971). The findings are often contradictory. For instance, Honorton (1969) and Morris (1969) and Cohen (1969) have obtained results suggesting a positive relationship between ESP and alpha. Lovin (1970), Carbone (1971) noted that there is negative relationship between ESP and alpha. An attempt has been made to solve this problem. Honorton, Davidson, and Binder (1971), together with other researchers, have attempted to obtain more concrete data on the nature of "psyfavorable" states of consciousness.

There have been fewer studies which relate alpha and performance. Kamiya (1969) examined EEG recordings for a number of speed readers and found they were "producing lots of alpha in strong amplitudes." The power reading process is based on a relaxed flowing, and turning on alpha gives a similar state of mind. Montor (1971) chose from the Naval Academy, two groups of 25 midshipmen each. One group consisted of midshipmen who had cumulative grade point averages between

3.50 to 4.00. The other group consisted of midshipmen who had cumulative grade point averages between 2.00 to 2.25. Montor then administered a variety of tests to measure their brain wave activity while resting, solving problems and under stress. The results indicated a significant difference in brain wave activity between the two groups. The high QPR group produced the greater amount of alpha.

Beside the successful associations of alpha with performance there were also some unsuccessful associations of alpha with performance. Kamiya (1971) attempted to determine whether subjects trained to control alpha amplitude would show improvement in a performance task if break periods from the task were used to maintain high alpha amplitude. The reasoning under this hypothesis was that alpha is often regarded as indicative of a resting or idling condition which may be characteristic of rest periods from performance tasks.

Five young male adults were given a battery of performance tasks with a four-minute break period between each task. The second group was told to merely wait for four minutes between tasks while the experimental group was trained to produce alpha and had four minutes of alpha feedback between tasks. The measures were verbal auditory vigilance, rod and frame, Guilford creative intelligence, visual memory, mental arithmetic, digit memory span, and tone tracking. The results were negative. The conclusion was that the self regulated high alpha break period did not facilitate task performance.

Beatty (1971) has studied the effect of alpha feedback on visual information performance. In this study, the two measures of information processing capacity utilized were

short term memory for digits and choice reaction times. The five best alpha-producing subjects were used in the short term memory study. Occipital alpha was monitored, and subjects were trained to either self-regulate alpha or beta activity. The entire experiment was conducted under digital computer control. Crucial to the assessment of the effects of auto-regulated EEG states on information processing, was the determination that the desired state was reached before the task was presented. On-line computer scanning of the EEG was employed preceding the delivery of information to the subject on each trial. Each trial was begun by an instruction for the subject to produce either the high alpha state or a beta state. A computer then began the process of sampling the EEG and measuring one wave each second to determine its period. When the desired EEG pattern was maintained for three seconds, the digits were presented. The data indicate that there was essentially no detectable difference in the efficiency with which most of the subjects process symbol digit strings when those strings are presented in periods of occipital alpha or beta frequency activity.

Thus, the theory presented from the beginning through this section of this paper promoted the following factors and relations. The human auditory sensitivity relates to nervous states, which are associated with the states of consciousness. Fatigue reduces auditory sensitivity. Biofeedback may be effectively used in altering states of consciousness. The alpha state is considered to be a relaxed, wakeful, alert state of consciousness. Several studies have related the

alpha state and performance. From a literature review, it became evident that no studies empirically related alpha and auditory sensitivity. Verbal reports indicated an alert of sensitivity state associated with alpha and this leads to the third line of inquiry.

Is the alpha state associated with a change in human auditory sensitivity? That is, does the auditory threshold vary during the alpha state?

II. METHOD AND PROCEDURES

A. DESIGN

In order to test the hypotheses, a 2 x 2 groups design was used as shown below.

	Feedback Training	Non Feedback Training
Meditator and Relaxed Persons	Group I	Group III
Non Meditators	Group II	Group IV

Group I: Meditators and relaxed persons with biofeedback training

Group II: Non meditators with biofeedback training

Group III: Meditators and relaxed persons without biofeedback training

Group IV: Non meditators without biofeedback training

All members of these groups were used to test hypotheses one and two. The members belonging to these groups who produced high percentage of alpha volume were used to test hypothesis three.

B. SAMPLE

Because of the substantial amount of time needed for alpha training sessions, randomization of the sample could not be accomplished. Instead, the subjects were all volunteers. Subjects being categorized as meditators were the ones who were recognized to have knowledge of meditation techniques

and who had been practicing meditation regularly and/or periodically. Subjects categorized as relaxed persons were the ones who were recognized as not being nervous and who state that they could empty their mind easily. The composition of the sample is as indicated in Table I.

Table I

The Sample Composition

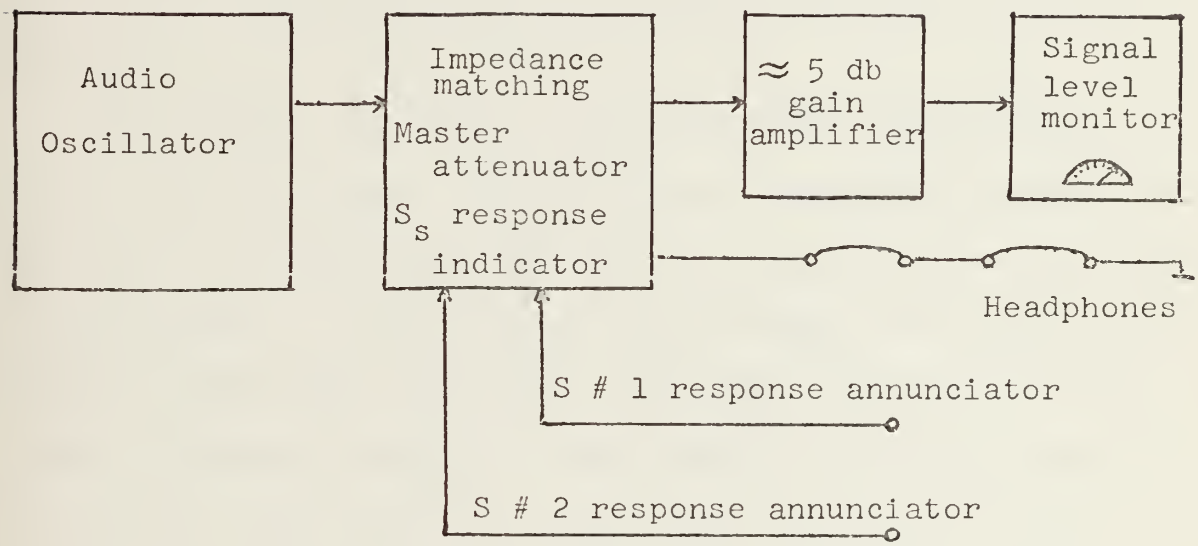
	Subject	Sex	Age	Education	Meditation Time
Group 1	1	M	33	College	2 years
	2	M	36	College	10 months
	3	M	31	College	5 years
	4	M	37	College	Relaxed
Group 2	5	F	55	College	2 years
	6	M	48	College	20 years
	7	M	28	College	Relaxed
Group 3	8	M	28	College	None
	9	M	29	College	None
	10	M	38	College	None
	11	M	28	College	None
Group 4	12	M	40	College	None
	13	M	33	College	None
	14	M	34	College	None
	15	M	41	College	None

C. APPARATUS

1. Auditory Threshold Sensitivity Testing Equipment

The auditory threshold sensitivity testing equipment consisted of the following: an audio oscillator to generate a tone, a signal level monitoring device, the subject's headphone and the response annunciators.

By manipulating the signal level monitoring device, a tone level generated by an audio oscillator may be varied by the experimenter. In using the response annunciator, the subject may give a signal back to the experimenter when he can hear or cannot hear the given tone. The auditory threshold sensitivity testing equipment is illustrated in the sketch below.



2. Biofeedback Equipment

a. Alpha Feedback Device

The experimenter used voice feedback, since an automated buzzer was not available. In so doing, the experimenter announced "alpha" to subjects through an intercom system when alpha brain waves appeared on the EEG graph paper or on the oscilloscope.

b. EEG Equipment

The EEG equipment used for alpha training was the Beckman RM recording machine. The brain waves generated by subjects were recorded on graph paper and displayed on an oscilloscope.

D. EXPERIMENTAL PROCEDURES

The experiment was conducted at the man-machine system design laboratory of the Naval Postgraduate School, Monterey, California. There were a total of nine sessions for each subjects.

The auditory threshold sensitivity test involved two, forty-minute sessions. Each sessions included 20 minutes for wiring. The length for auditory threshold sensitivity testing was 20 minutes. These sensitivity sessions took place on the first and the ninth sessions. The alpha training involved seven, 40-minute sessions. Each session included 20 minutes for wiring. The length for alpha training was 20 minutes. These sessions took place from the second to the seventh sessions.

Upon arrival at the experimental situation, each subject was briefly advised of the purpose of the experiment and of the importance to the experimenter of the subject doing his best. Moreover, each subject was recommended to make daily notes concerning his feelings before, during and after each alpha training session. These written impressions were submitted to the experimenter at the end of the training period

for use in the evaluation of alpha training of each subject. In the course of the general briefing, surface electrodes serving as EEG pickups were applied to the subjects. The electrode wiring consisting of placing the three electrodes at the proper place of the head. For the left part of the head, the first electrode used as grounding was placed at the lower part of the ear lobe (position A_1). The second electrode was placed one inch on the left of the parieto occipatal lobe (position O_1). The third electrode was placed at one inch to the left of the occiptal lobe (position C_3). For the right part of the head, the electrodes would be applied at the position A_2, O_2 and C_4. These position symbols are in accordance with the international (10 - 20) electrode placement conventional system.

In order to see if there is any difference in the alpha production from the left or the right side of the brain, each session, the electrodes were alternatively placed on the left then the rigth hemisphere. The subject was, then, moved into an 8' x 10' booth which served as an experimental area, seated in an easy armchair, and instructed to rest quietly for approximately three minutes. In this time, the auditory threshold sensitivity testing equipment and brain wave recording apparatus was hooked and calibrated. At the conclusion of this time period, the subject was given detailed instructions for his task (presented in Appendix A).

To determine the auditory threshold, each subject was instructed about how and when to monitor the response annunciator. In each of two sessions of auditory threshold

measurement, before the real testing process began, the subject had three minutes of practice to use the response annunciator.

In the first session, subject's auditory threshold was measured during a normal state of consciousness. During the session, the subject was instructed to keep the eyes open and to behave normally. The auditory threshold was then measured by method of limits.

The ninth session was used to measure auditory threshold under alpha state. The process of measuring auditory threshold with the method of limits was the same, as in the first session except that the subject was instructed to have eyes closed and to generate as much alpha as possible. The experimenter gave the subject a stimulus when the subject's alpha waves were abundant and continuously seen on the EEG graph paper or on the oscilloscope. The calculation of the subject's absolute threshold was conducted according to method of limits (methods of limits is presented in detail in Appendix B).

The alpha training took place from the second session to the eighth session. Those subjects who were supposed to be trained to produce alpha with biofeedback were instructed through the intercom system concerning the signal given by the experimenter. They were told to sit still with closed eyes and to try to relax. These subjects were also told that the "alpha" announcement would occur when they produced alpha. They were asked to maintain the same state they were in when the "alpha" announcement was given.

Subjects who were supposed to be trained in alpha production without biofeedback were told to sit still with their eyes closed. They were also told to relax and to produce alpha by themselves.

The brain waves of each subject were recorded by the pen recording of a Beckman RM recording machine. The percentage of alpha of each subject was measured by the experimenter after each session.

III. RESULTS

A. BIOFEEDBACK TRAINING

The biofeedback training performance of 15 subjects composed of seven meditators/relaxed persons and eight non meditators were evaluated by measuring their percentage of alpha production in seven sessions. The data collected in these experiments are shown in Table II.

Table II

Percentage of Alpha Produced During Each Session

	Meditator & Relaxed Persons With Feedback				Meditator & Relaxed Persons Without Feedback			
Session	S_1	S_2	S_3	S_4	S_5	S_6	S_7	
2	18	12	50	48	20	58	20	
3	38	18	52	53	26	60	19	
4	30	23	40	60	21	62	21	
5	43	24	59	62	22	70	21	
6	35	28	63	63	20	64	34	
7	33	32	60	63	20	57	39	
8	41	30	72	60	29	50	18	
	Non Meditators With Feedback				Non Meditators Without Feedback			
	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}
2	8	43	18	15	10	10	9	10
3	8	47	21	15	12	12	15	7
4	15	44	20	22	11	15	6	5
5	20	56	25	26	22	11	14	2
6	21	56	15	28	16	25	25	1
7	23	48	17	29	18	20	20	1
8	30	44	22	36	20	22	16	1

A comparison of percentage alpha production of meditators and relaxed persons with non meditators is illustrated in Figures 1 and 2.

From these two figures, it is noted that the majority of the meditators produced a higher percentage of alpha than the non meditators. In supporting this, Figure 3 illustrates the average percentage of alpha production for the two above mentioned groups. An analysis of the significant difference between the population means of percentage of alpha produced by meditator and relaxed person group (μX_A) and non meditator group (μY_A) were conducted.

The Null hypothesis derived from this test which was rejected at the 5% level of significance as seen from the derived 95% confidence interval, confirms the significant difference of these two population means. (Details of the analysis are presented in Appendix C-IIa.)

Moreover, a t test was also conducted and the results are summarized in Table III.

Table III

T Test Results

	Mean of % of alpha	N	S^2	t	df	P
Meditator & Relaxed Person Group	40	7	320.1	6.530	103	0.05
Non Meditator Group	20.2	8	167.7			

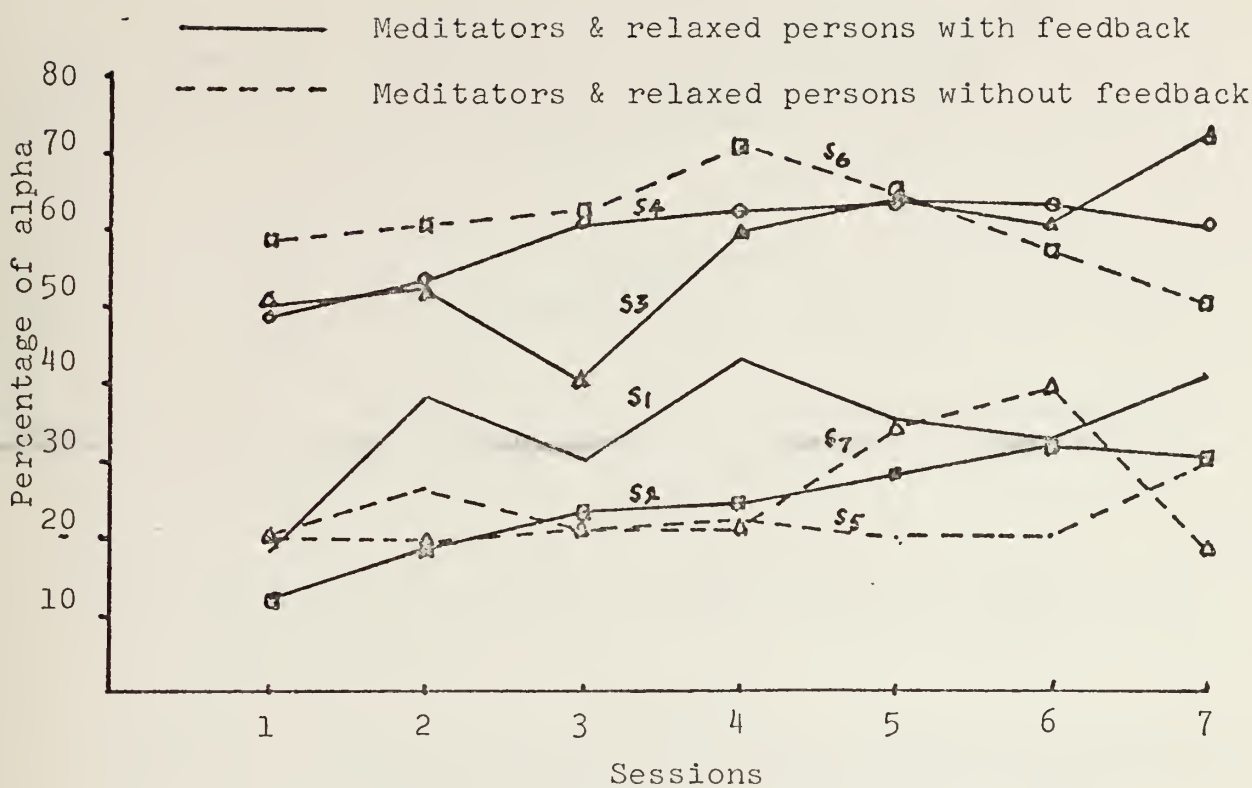


Figure 1. Percentage of Alpha Produced by Meditators and Relaxed Persons

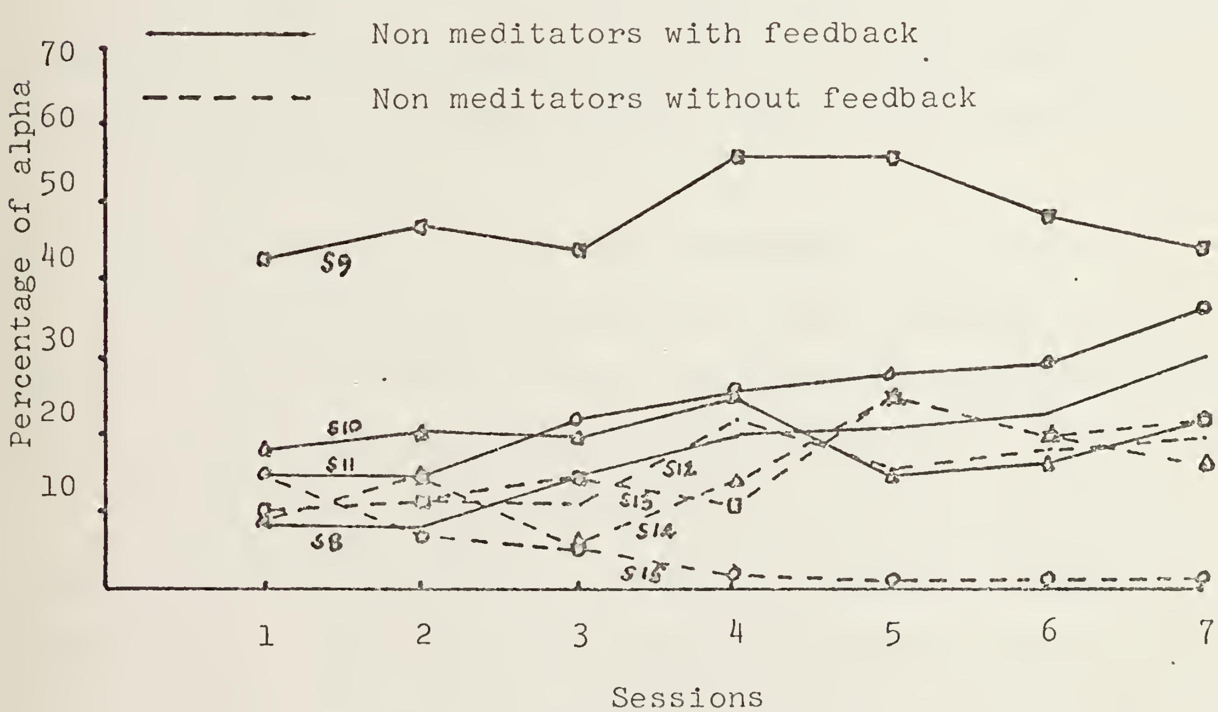


Figure 2. Percentage of Alpha Produced By Non Meditators

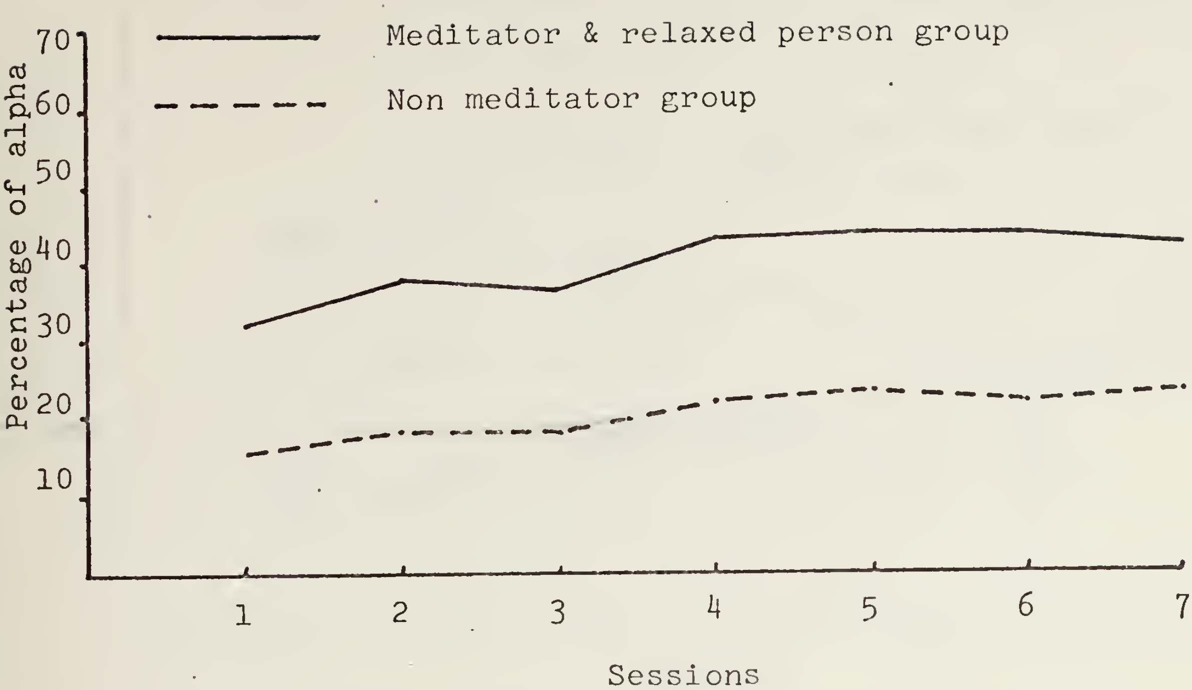


Figure 3. Average Percentage of Alpha Produced by Meditator & Relaxed Person and Non Meditator Groups

The value of t shown in this table indicates a significant difference between the mean percentage of alpha produced by the meditators and relaxed persons, and the non meditators at .05 level of significance.

Thus, hypothesis one is then confirmed.

A comparison of the percentage of alpha production of subjects being provided feedback training with subjects not given feedback training is illustrated in Figures 4 and 5.

From these two figures, it is noted that the majority of subjects being trained with biofeedback produced a higher percentage of alpha than the ones being trained without feedback. Figure 6 illustrates the net difference between average percentage of alpha of these two groups of subjects. An

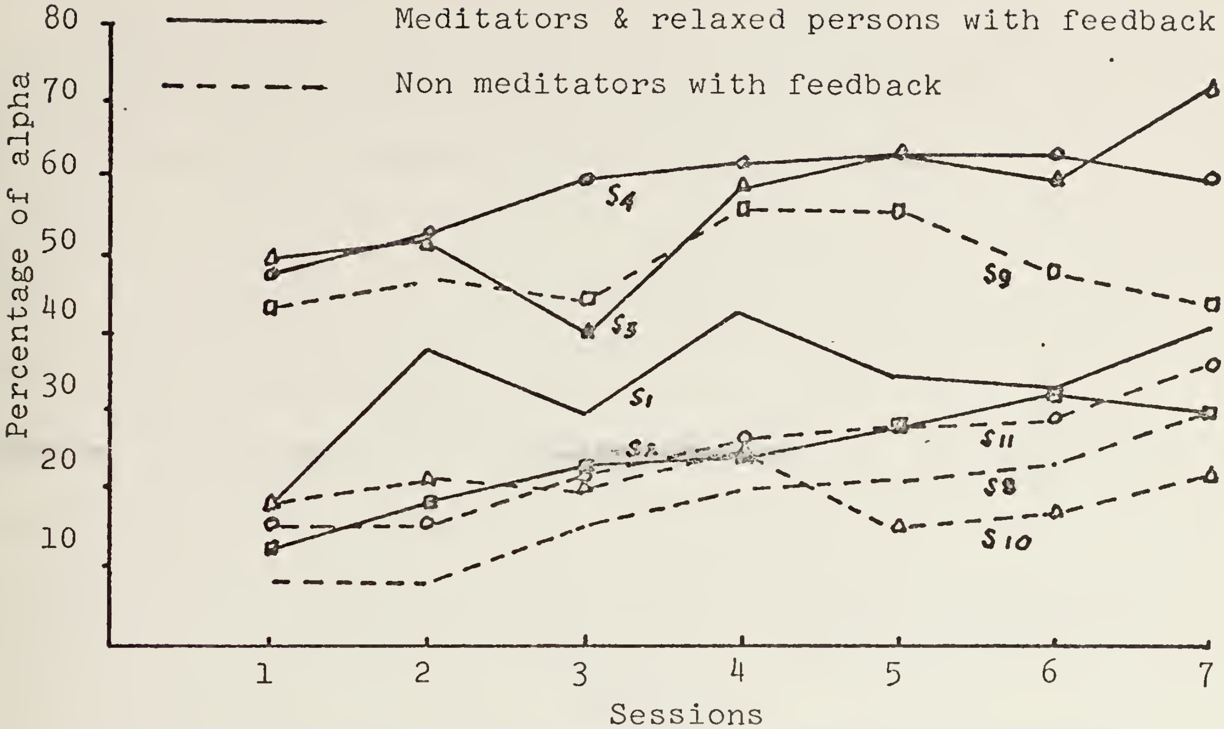


Figure 4. Percentage of Alpha Produced By Subjects With Feedback

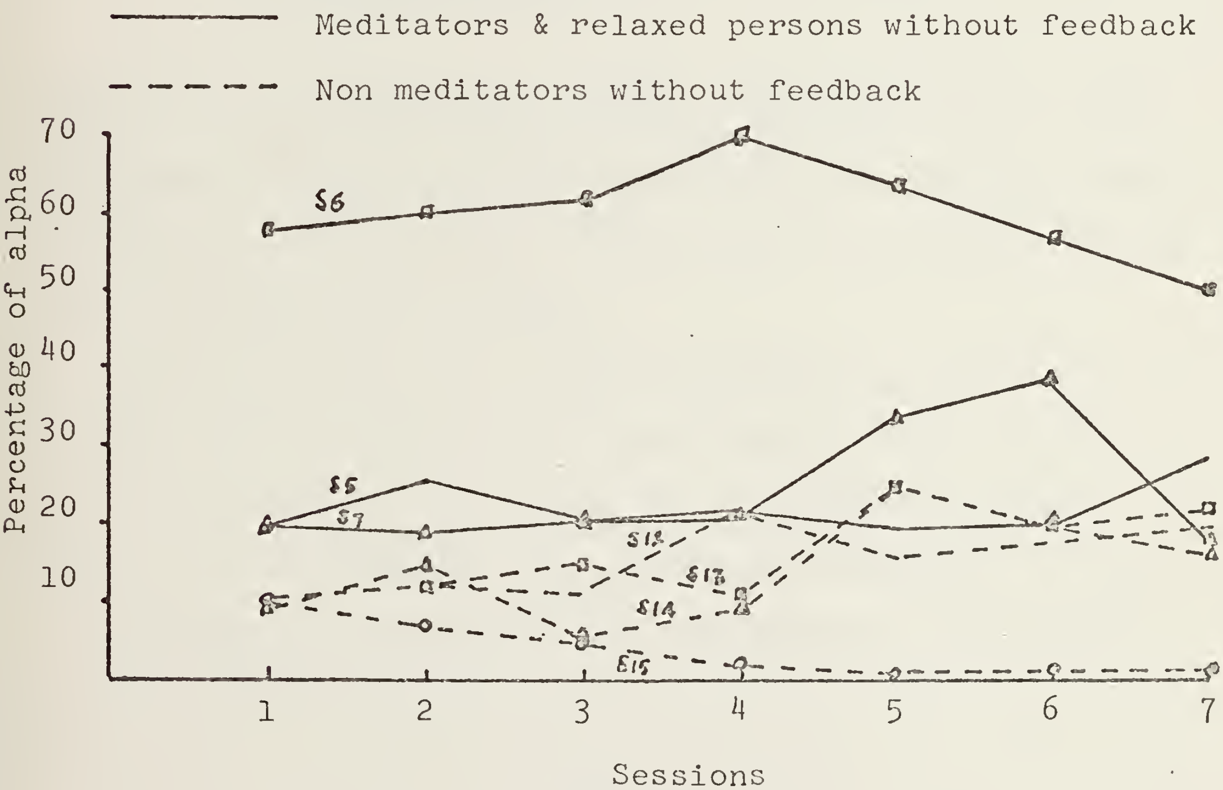


Figure 5. Percentage of Alpha Produced By Subjects Without Feedback

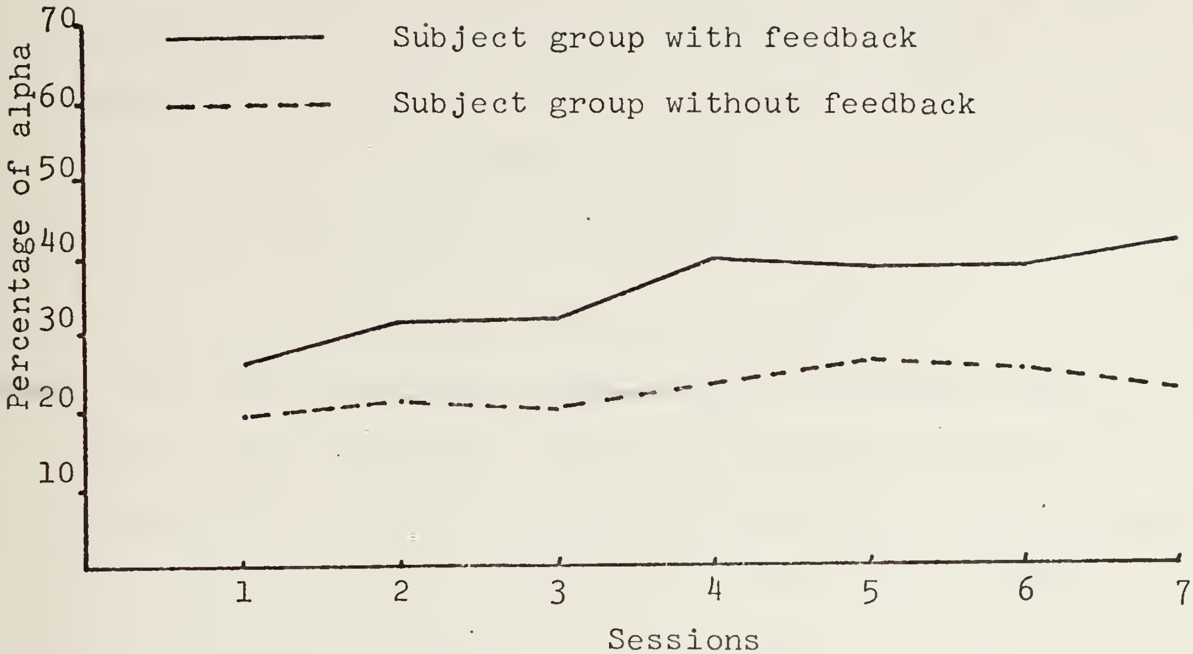


Figure 6. Average Percentage of Alpha Produced By Subject Groups Being Provided Feedback and Not Being Provided Feedback

analysis of the difference between population means of the percentage of alpha produced by the group of subjects using biofeedback training (μX_B) and the ones not using biofeedback training (μY_B) was conducted.

The Null hypothesis derived from this test which was rejected at the .05 level of significance confirmed the significant difference between the two population means. (Details of the analysis are presented in Appendix C-IIIa).

Moreover, a t test was also conducted and the results are summarized in Table IV.

Table IV

T Test Results

	Mean of % of alpha	N	S^2	t	df	P
Feedback Group	35.4	8	289.3	3.773	103	.05
Non Feedback Group	22.6	7	307.0			

The value of t shown in Table IV indicates the significant difference between the mean percentage of alpha produced by subjects being provided feedback training and the subjects not being provided feedback training.

Thus, hypothesis two is confirmed.

B. AUDITORY THRESHOLD SENSITIVITY TESTING

In order to evaluate the auditory threshold sensitivity under normal and alpha state, five subjects producing the highest percentage of alpha were selected to measure auditory threshold during the alpha state. The value of their ascending and descending thresholds obtained from these two states are shown in Table V.

From Table V, it is noted that the ascending auditory thresholds were generally lower during alpha state, while the descending thresholds were slightly improved. The values of auditory absolute thresholds were computed and presented in Table VI.

From Table VI, it is noted that the auditory absolute thresholds of all five subjects improved slightly.

An analysis of the significant difference between population means of the auditory thresholds sensitivity under normal state and alpha state was conducted.

The Null hypothesis derived from this test, which could not be rejected at the .05 level of significance as seen from the derived 95% confidence interval indicates that the difference of these two population means is insignificant. (Details of the analysis are presented in Appendix C-IIIa.)

Table V

Ascending and Descending Auditory Threshold Sensitivity

Under Normal and Alpha State in Relative Units

	S_1		S_2		S_3	
Observation	Normal	Alpha	Normal	Alpha	Normal	Alpha
	Ascending		Ascending		Ascending	
1st	4	5	6	7	5	6
2nd	3.5	4	6	7	5	6
5th	5	5	6	6	6	4
6th	4	5	6	7	6.5	6
	Descending		Descending		Descending	
3rd	8	7	5	4	6	5
4th	8	8	5	4.5	7	5
7th	8	6	5.5	4	7	4.5
8th	8	5	5.5	4	6	6

	S_4		S_5	
	Ascending		Ascending	
1st	7	8	9	8
2nd	8	7.5	9	8
5th	7	8	9	6
6th	7	8	9	7
	Descending		Descending	
3rd	6	5	6.5	7
4th	6	5	6	6.5
7th	6	4	7	7
8th	6	4	6	7

Moreover, a t test was conducted and the results are summarized and presented in Table VII.

Table VI

Absolute Thresholds Obtained Under Normal and Alpha State in Relative Units

Subject	Normal State	Alpha State
S_1	6.06	5.625
S_2	5.625	5.43
S_3	6.06	5.18
S_4	6.62	6.18
S_5	7.68	7.06

Table VII

Summarization of T Test Results of Thresholds Analysis Under Alpha and Normal State

	Mean of Thresholds	N	S^2	t	df	P
Threshold Under Normal State	6.408	5	1.98	1.636	78	N.S.*
Threshold Under Alpha State	5.894	5	2.78			

* not significant

The t value shown in Table VII had demonstrated the insignificant difference between thresholds measured under normal state and alpha state.

Thus, hypothesis three is rejected. There is no significant auditory threshold sensitivity improvement during the alpha state as compared with the normal state.

IV. DISCUSSION

A. BIOFEEDBACK TRAINING

Significant differences between the percentage of alpha production by meditators or relaxed persons and non meditators, by subjects being feedback and not being feedback were revealed in the results of laboratory experimentation presented in Chapter III.

Evidence was presented which supported the hypothesis that meditators or relaxed persons generate more alpha than the non meditators. The results in Table II indicate that this difference is statistically significant at the .05 level.

In reviewing the percentage of alpha production of each subject in Figures 1, 2, 4 and 5, it was noted that some subjects belonging to the non meditation group produced a higher percentage of alpha than some subjects belonging to the meditation group. It was also noted that some subjects belonging to non feedback training group produced a higher percentage of alpha than some subjects belonging to the feedback training group. For the latter case, subject six's high alpha production could be explained by comparing his meditation time of over 20 years to the meditation time of the other subjects which have been just a couple of years.

Moreover, qualitative data acquired from the subjects' verbal report after each session, and subjects' written report after the training period, it was noted that:

Meditators spending years in meditation may increase or decrease the amount of alpha produced daily.

Meditators who were newly involved in meditation generated non homogenous amount of alpha, due to their attempt in testing different techniques of meditation.

Non meditators being provided feedback enjoyed controlling their minds very much.

Hypothesis one is supported by similar results found by different researchers (Kamiya, 1967, 1968; Wallace, 1970) and is further justified by Lynch and Paskewitz (1971) when these two researchers noted that the mental blankness and abstract thinking were associated with alpha activity. In additiion, by referring back to the psychology of meditation of Zen and transcendental meditation, Kasamatsu and Hirai (1969) stated that "by practicing meditation, it is said that man can become emancipated from the dualistic bondage of subjectivity and objectivity of mind and body and of birth and death. And he can be awakened to his pure sense and true self." Maharishi (1969) emphasized that "TM is neither a matter of concentration nor contemplation. The process of concentration and contemplation each hold the mind on the conscious thinking level, whereas transcendental meditation systematically take the mind to the source of thought the pure field of creative intelligence." These processes in conjunction with the reported state of pleasant relaxation of meditator subjects in Kamiya's study in 1969 explain further that people who have experienced their physiological change may produce more alpha than the ones who have not been experienced in these states of mind.

Evidence was presented which also supported the hypothesis that the subjects being provided feedback generate more alpha than the subjects not being provided feedback. Table III indicates that there is a significant difference at the .05 level. Feedback seems to produce a marked effect on the percentage of alpha generated.

This hypothesis two is supported by similar results found by different researchers. Kamiya (1962), Mulholland and Evans (1966), Dewan (1967), Hart (1967) noted that feedback via an external path permits the subjects to receive information about processes which are not presented in subjective consciousness. For instance, subjects are not aware of their brain rhythms. They cannot learn to control the occurrence of alpha without feedback. However, with feedback stimulation which informs the subject when the alpha is off or on, a subject can control his alpha rhythm. Simonov and Velueva (1966) state that control of physiological processes as seen in the highly skilled practiced of Yoga or in the trance state of the mystic required years of training. The voluntary control of these processes may be more efficiently learned using feedback training permitting an increase in the range of psychological experiences associated with physiological changes for more people. Feedback presented may act as a signal or cue for the person to attend to what his particular condition feels like. Perhaps through feedback the person can focus on the feeling at the moment and learn to recognize that state and maintain it.

Due to the verbal report after each experimental session and by the investigation of the written report submitted to the experimenter after the subjects' experimental period, it is noted that the majority of the subjects expressed the feeling of relaxation. This was the same as the other researchers who have found from their subjects that the alpha state is described as a relaxed state. (Green, 1961; Walters, 1961; Murphy 1961). However, there were some subjects from the non meditator group who generated much alpha, stated that they were not relaxed during alpha state. They felt tired and some got headaches for four to five hours after each alpha training session. This leads to the other phsyiological effects between alpha and mental state, which are necessary to be investigated.

Finally, some subjects who were meditators expressed the feeling that the Zen meditation technique may help to generate alpha more easily than the transcendental meditation technique.

B. AUDITORY SENSITIVITY THRESHOLDS UNDER ALPHA STATE

The insignificant difference between the population means of the thresholds under normal state and alpha state, together with the decrease in ascending thresholds under alpha state of the five subjects presented in Table V had further supported the unsuccessful experimentation results conducted by Kamiya (1971) and Beatty (1971) when these two researchers tried to relate alpha to perceptual sensitivity performance. The two experiments conducted by Kamiya (1971) and Beatty (1971) were presented in Chapter I, Part D.

The results of all three studies indicated that merely associating a specific physiological state with effective performance is conceptually too simple. It appears that even with a single subject, effective performance can be maintained by varying psychological states and, indeed, that the internal state should probably vary depending upon the requirement of the particular subject and the particular task. Remember Hebb's (1949) on optimal levels of arousal associated with particular activity. To assume that a particular amount of alpha would always be associated with more efficient cognitive functioning does not seem tenable. Thus, the goals of many of the researchers to find physiological correlates of effective performance will probably not be successful when taken across individuals, even if a particular correlate could be identified within a single individual.

During the threshold sensitivity evaluation, it was noted that, in the ascending threshold measurement phase, when the subject first perceived the tone given by the experimenter, his alpha was blocked. This event agrees with Ornes and Paskewitz's (1971) report. These researchers noted that when given a complex task, subjects trained in alpha control did not continue to produce alpha, but instead showed consistent alpha blocking. This phenomenon has been known for many years and thus was hardly a new finding. However, listening to a tone is hardly a complex cognitive task. The results in Table VI, although not statistically different at .05 level of significance, are all in the same direction. Perhaps with

further training, the difference between auditory thresholds during normal and alpha states would be larger.

V. SUGGESTIONS FOR FURTHER STUDIES

Because of the tight resource constraints and the limited time available, the study was conducted with a small sample size, fewer sessions, and a less appropriate amount of equipment than desired for experimenter. Therefore, the study made and presented in this paper might be considered as a pilot study.

In order to express a firm conclusion about alpha training and the relation between alpha and human auditory sensitivity, it is suggested that this research be continued with the following recommendations.

1. Use two larger groups of subjects consisting of meditators and non meditators.

2. Meditators should be selected from the ones who have spent many years in meditation and from different types of meditation (Zen, Yoga, TM, etc.).

3. More sessions should be used so that subjects gain more experience in the alpha training process. This should give a more legitimate test of the relationship between the alpha state and auditory sensitivity. More sessions would also increase the familiarity of the alpha state to the subjects and thus it should make it easier to recognize what the alpha state "feels" like.

4. Biofeedback equipment should use the buzzer instead of voice feedback.

5. Auditory sensitivity thresholds measurement equipment must be adequate and precise.

6. Give more comfort to the subjects by minimizing noises coming from the outside of the experimental booth.

7. Better equipment to put electrodes on the subject's head.

APPENDIX A

INSTRUCTIONS TO SUBJECTS

1. You are going to be involved in nine sessions of experimentation in this laboratory to be evaluated about your auditory threshold sensitivity under normal state and alpha state, and to be measured in the percentage of alpha generated during the alpha training period. Auditory threshold evaluation will take place on the first and on the ninth sessions. The alpha training period will be from the second to the eighth sessions.

2. You may have your own ideas about an experiment of this type, but you are asked to forget all that you know or have heard and follow instructions are presented to you.

3. During the experiment, the communication between you and the experimenter will be conducted through the intercom system.

4. As mentioned in part 1, the first session is the auditory threshold sensitivity testing under normal state. You are requested to have eyes opened and pay attention to the tone given by the experimenter through the headphone you wear. The experimenter will ask you to push the annunciator located on your right or left side of your seat, either when the tone is given or when it disappears according to the requirement of the experiment. Before the session you will have three minutes to practice this.

5. From the second to the eighth sessions, you will conduct the alpha training with (without) feedback. During these sessions, you are asked to sit still and relax as much as you can. For those who are supposed to conduct alpha training with feedback the voice announcement of "alpha" will be provided when you generate alpha. You are asked to recognize the alpha state of mind and keep it on in order to generate as continuous alpha as possible. When you don't hear the alpha feedback, calm your mind and relax to regain the alpha announcement. For those who are supposed to conduct alpha training without feedback, you are requested to sit still and relax to generate alpha by yourself.

6. In the ninth session, those who generate high percentage of alpha will be asked to participate in the auditory threshold sensitivity under alpha state. In this session, you are requested to have eyes closed and generage as much alpha as possible. Like the first session, you will push the annunciator when the tone is given or when it disappears following the experimenter's recommendations.

7. During the alpha training period, when you relax, you will easily fall asleep. So, try to relax, but not to sleep, because alpha may only be generated when you are relaxed.

8. Throughout the experiment, it will be important to notify that you minimize body movement. You will probably find it necessary, however, to shift your position from time to time. By all means, feel free to do so. The experimenter only asks that when you must move, get yourself readjusted comfortably

and then to remain still. An occasional movement is much better than continuous fidgeting.

9. After each session, you are requested to note your feelings about before, during and after the experiment. This note will be submitted to the experimenter at the end of the experimental period for use in the evaluation of your alpha training status.

10. Thank you for your assistance. Do you have any questions?

APPENDIX B

MEASURING THRESHOLD BY METHOD OF LIMITS

1. The Problem

The method of limits is one of the most frequently used methods for determining the absolute threshold. In psychophysics, the absolute threshold or stimulus limen, is given an operational definition that corresponds to the value of the stimulus that is detected and reported by an observer on fifty percent of the trials (Corso, 1967).

The fundamental notion is that in any psychological study, there are three quantitative variables involved. One of these variables is on a physical or stimulus continuum, the second, on a subjective continuum, and the third, on a judgment continuum. It is assumed that the latter two variables are linearly and perfectly correlated. This means that, given certain data on the judgment continuum, implication may be drawn concerning the nature of the occurences on the subjective (sensory) continuum.

It has also been pointed out that a given phsyical continuum usually extends from an infinitely small value (theoretically the lower limit of zero) to some finitely large magnitude. The range of this continuum is, therefore, so great that the organism is incapable of responding either to the exceedingly small quantities of the property under consideration, or to the exceptionally large quantities. Thus,

the subjective continuum may be considered to be shorter than the physical continuum at both ends.

The concept of the absolute threshold applies to the lower end of the phsyical continuum. It is the value on the physical continuum which separates the stimuli that are not capable of eliciting a behavioral response from those that are. At the upper end of the physical continuum, the terminal stimulus, or terminal limen, is a value on the continuum which separates the stimuli that are capable of eliciting a behavioral from those that are not. In either case, there is an underlying zone of transition on the subjective continuum which leads to a change in the type of behavioral response made by the observer.

The notion of a zone of transition implies that the exact location of the absolute threshold varies from moment to moment as measured over a given portion of the physical continuum. The variation may be due to a large number of factors such as extraneous "noise" in the nervous system, fluctuations in attention, change in the criterion of response and so on. The result is that random variations in sensitivity are invariably observed in psychophysical experiments. Consequently, a number of observations must be made in determining the threshold value. This generates a distribution of observations that encompass the transition zone. On the basis of this distribution, the stimulus limen is given a statistical definition. It corresponds to the central tendency (usually the arithmetic mean) of the distribution of observations.

2. The Procedure

A basic requirement of the method of limits is that the stimulus must be variable in small discrete steps of equal physical magnitude. This requirement is easily met in the determining of absolute threshold for tone. The experimenter presents a series of stimuli, each differing by a small amount from the preceding one. For each stimuli in the series, the experimenter records the response of the observer.

In the determination of an absolute threshold, two kinds of stimulus series are generally employed: an ascending series and a descending series. In the ascending series, the initial stimulus of the series is presented well below the threshold and, on each suceeding trial, the experimenter increases the magnitude of the stimulus by a constant small step until the observer detects the presence of the stimulus and gives a positive response. In the descending series, the initial stimulus of the series is presented well above the threshold and, on the suceeding trial, the experimenter decreases the magnitude of the stimulus by constant small steps until the observer can no longer detect the presence of the stimulus and gives a negative report. Each series is stopped as soon as the observer's report changes from "+" to "-" or from "-" to "+" depending on the direction of the series.

In determing a threshold value, the experimenter usually employs several ascending and descending series. These two types of series may be presented in alternation: for example, descending, ascending, descending, ascending. They could

also be presented in a prearranged sequence, with the total number of ascending trials being equal to the total number of descending trials.

The use of both ascending and descending trials tends, in the computation of the absolute threshold, to cancel out two constant errors which may occur in the method of limits. These are the error of habituation, in which the observer tends to give the same response for too many trials within the given series for example, "yes" in a descending series and "no" in an ascending series and the error of expectation in which the observer prematurely changes his response from negative to positive, or from positive to negative, because he thinks a change should have occurred in view of the number of trials or the amount of time that has elapsed since the beginning at the particular series.

3. The Computation

To illustrate the computation of the absolute threshold in the method of limits, suppose than an experiment has been performed to determine the auditory absolute threshold. Assume that by means of a sound generator, a series of graduated sounds was provided to an auditory system in accordance with the requirement of the method of limits. Assume also that the results for one observer in such an experiment are in the table shown below in which the magnitude of the stimulus is specified in decibels. The "+" sign indicates a positive report, and the "-" sign indicates a negative report.

Determination of the Auditory Absolute Threshold
By Method of Limits
(Ficticious Data)

Stimulus in Decibels	Descending	Ascending	Descending	Ascending	Descending	Ascending
21	+					
20	+					
19	+				+	
18	+				+	
17	+				+	
16	+				+	
15	+		+		+	
14	+		+		+	
13	-		+	+	+	
12		+	+	-	-	
11		-	+	-		+
10		-	+	-		-
9		-	-	-		-
8		-		-		-
7		-		-		-
6				-		
5				-		
Threshold Series	13.5	11.5	9.5	12.5	12.5	10.5

Descending threshold = (13.5 + 9.5 + 12.5)/3 = 11.8 decibels

Ascending threshold = (11.5 + 12.5 + 10.5)/3= 11.5 decibels

Absolute threshold + (11.8 + 11.5)/2 + 11.65 decibels

There are three descending and three ascending trials presented in alteration. Each series yeilds a threshold value. This value is taken as the midpoint between the stimulus magnitude which terminates a series and the stimulus magnitudes immediately preceding it. For instance, in the first descending trial shown in the table, the absolute threshold is taken to be 13.5 decibels. However, a more reliable estimate of threshold may be obtained by averaging the values obtained in each

of the six series. A common procedure for doing this is to average the threshold values for all descending series to obtain a descending threshold, and to average the threshold values for all ascending series to obtain an ascending threshold. The absolute threshold is then obtained by finding the mean of these two estimates.

APPENDIX C

Table IIa

Statistical Analysis of significant difference between population mean of percentage of alpha produced by meditator and relaxed person and non meditator groups.

1.

$X_A \equiv$ percentage of alpha produced by each meditator and relaxed person in each session

$Y_A \equiv$ percentage of alpha produced by each non meditator in each session

$\mu X_A \equiv$ population mean of percentage of alpha produced by meditators and relaxed persons

$\mu Y_A \equiv$ population mean of percentage of alpha produced by non meditators

$$\sum_{i=1}^{49} X_A^2 = 93{,}765 \qquad \overline{X}_A = 40$$

$$\sum_{i=1}^{56} Y_A^2 = 32{,}067 \qquad \overline{Y}_A = 20.2$$

$$S_{X_A}^2 = \frac{\sum_{i=1}^{49} X_A^2 - 49\overline{X}_A^2}{48} = \frac{93{,}765 - 78{,}400}{48} = 320.1$$

$$S_{Y_A}^2 = \frac{\sum_{i=1}^{56} Y_A^2 - 56\overline{Y}_A^2}{55} = \frac{32{,}076 - 22{,}850}{55} = 167.7$$

Under H_0: $$\frac{(\overline{X}_A - \overline{Y}_A) - (\mu_{X_A} - \mu_{Y_A})}{\hat{\sigma}\sqrt{\frac{1}{n} + \frac{1}{m}}} \sim t_{n+m-2} \text{approx } N(0,1)$$

95% confidence interval for $(\mu_{X_A} - \mu_{Y_A})$ is

$$(\bar{X}_A - \bar{Y}_A) \pm 1.96\, \hat{\sigma} \sqrt{\frac{1}{n} + \frac{1}{m}}$$

$$40 - 20.2 \pm 1.96 \times 15.4 \times 0.195$$

$$19.8 \pm 5.88$$

$$(13.92, 25.68)$$

$$\left\{ \begin{aligned} \hat{\sigma} &= \sqrt{\frac{48 S_{X_A}^2 + 55 S_{Y_A}^2}{103}} \\ &= \sqrt{\frac{15365 + 9226}{103}} \\ &= 15.4 \\ \sqrt{\frac{1}{n} + \frac{1}{m}} &= 0.195 \end{aligned} \right.$$

Null hypothesis for $\mu_{X_A} = \mu_{Y_A}$ is rejected

2. t test

$$t = \frac{\bar{X}_A - \bar{Y}_A}{\sqrt{\frac{(n-1)S_{X_A}^2 + (m-1)S_{Y_A}^2}{n+m-1} \left(\frac{1}{n} + \frac{1}{m}\right)}}$$

$$t = \frac{40 - 20.2}{\sqrt{\frac{(48)(320.1) + (55)(167.7)}{103} \left(\frac{1}{49} + \frac{1}{56}\right)}} = 6.530$$

$t^* = 1.986$

df = n+m-2 = 103

P = .05

H_0 is rejected at .05 level of significance

Table IIIa

Statistical Analysis of significant difference between population mean of percentage of alpha produced by subject group being feedback and not being feedback.

1.

X_B ≡ percentage of alpha produced by each subject being feedback in each session

Y_B ≡ percentage of alpha produced by each subject not being feedback in each session

X_B ≡ population mean of percentage of alpha produced by subjects with feedback

Y_B ≡ population mean of percentage of alpha produced by subjects without feedback

$$\sum_{t=1}^{56} X_B = 86{,}074 \qquad \overline{X}_B = 35.4$$

$$\sum_{t=1}^{49} Y_B = 39{,}767 \qquad \overline{Y}_B = 22.6$$

$$S_{X_B}^2 = \frac{\sum_{t=1}^{56} X_B^2 - 56\overline{X}_B^2}{55} = \frac{86{,}074 - 70{,}177}{55} = 289.3$$

$$S_{Y_B}^2 = \frac{\sum_{t=1}^{49} Y_B^2 - 49\overline{Y}_B^2}{48} = \frac{39{,}767 - 25{,}027}{48} = 307.0$$

Under H_0: $$\frac{(\overline{X}_B - \overline{Y}_B) - (\mu_{X_B} - \mu_{Y_B})}{\hat{\sigma}\sqrt{\frac{1}{n} + \frac{1}{m}}} \sim t_{n+m-2} \text{approx } N(0,1)$$

95% confidence interval for $(\mu_{X_B} - \mu_{Y_B})$ is

$$(\bar{X}_B - \bar{Y}_B) \pm 1.96\, \hat{\sigma} \sqrt{\frac{1}{n} + \frac{1}{m}}$$

$$35.4 - 22.6 \pm 1.96 \times 17.2 \times 0.195$$

$$12.8 \pm 6.57$$

$$(6.23, 19.37)$$

$$\hat{\sigma} = \sqrt{\frac{55 S_{X_B}^2 + 48 S_{Y_B}^2}{103}}$$

$$= \sqrt{\frac{15.897 + 14,740}{103}}$$

$$= 17.2$$

$$\sqrt{\frac{1}{n} + \frac{1}{m}} = 0.195$$

Null hypothesis for $\mu_{X_B} = \mu_{Y_B}$ is rejected.

2. t test

$$t = \frac{\bar{X}_B - \bar{Y}_B}{\sqrt{\frac{(n-1)S_{X_B}^2 + (m-1)S_{Y_B}^2}{n+m-2}\left(\frac{1}{n} + \frac{1}{m}\right)}}$$

$$= \frac{35.4 - 22.6}{\sqrt{\frac{(55)(289.3) + (48)(307.0)}{103}\left(\frac{1}{56} + \frac{1}{49}\right)}}$$

$t = 3.773$

$df = n+m-2 = 103$

$t^* = 1.986$

$P = 0.05$

H_0 is rejected at 0.05 level of significance.

Table VIa

Statistical analysis of significant difference between population mean of thresholds under normal state and alpha state.

1.

$X_C \equiv$ threshold of each subject measured in each trial in normal state

$Y_C \equiv$ threshold of each subject measured in each trial in alpha state

$\mu_{X_C} \equiv$ population mean of threshold measured in normal state

$\mu_{Y_C} \equiv$ population mean of threshold measured in alpha state

$$\sum_{i=1}^{40} X_C^2 = 1{,}720.25 \qquad \overline{X}_C = 6.408$$

$$\sum_{i=1}^{40} Y_C^2 = 1{,}498 \qquad \overline{Y}_C = 5.894$$

$$S_{X_C}^2 = \frac{\sum_{i=1}^{40} X_C^2 - 40\,\overline{X}_C^2}{39} = \frac{1{,}720.25 - 1{,}642.4}{39} = 1.98$$

$$S_{Y_C}^2 = \frac{\sum_{i=1}^{40} Y_C^2 - 40\,\overline{Y}_C^2}{39} = \frac{1{,}498 - 1{,}389.6}{39} = 2.78$$

Under H_0: $$\frac{(\overline{X}_C - \overline{Y}_C) - (\mu_{X_C} - \mu_{Y_C})}{\hat{\sigma}\sqrt{\frac{1}{n} + \frac{1}{m}}} \sim t_{n+m-2} \text{ approx } N(0,1)$$

95% confidence interval for $(\mu_{X_C} - \mu_{Y_C})$ is

$$(\bar{X}_C - \bar{Y}_C) \pm 1.96\,\hat{\sigma}\ \frac{1}{40} + \frac{1}{40}$$

$$6.408 - 5.894 \pm 1.96 \times 1.54 \times 0.223$$

$$0.514 \pm 0.673$$

$$(-0.159, 1.87)$$

$$\left\{\begin{aligned} \hat{\sigma} &= \sqrt{\frac{39S_{X_C}^2 - 39S_{Y_C}^2}{78}} \\ &= \sqrt{\frac{108.4 + 77.85}{78}} \\ &= 1.54 \end{aligned}\right.$$

Null hypothesis for $\mu_{X_C} - \mu_{Y_C}$ cannot be rejected at .05 level of significance.

2. t test

$$t = \frac{\bar{X}_C - \bar{Y}_C}{\sqrt{\frac{(n-1)S_{X_C}^2 + (m-1)S_{Y_C}^2}{n+m-2}\left(\frac{1}{n} + \frac{1}{m}\right)}}$$

$$\frac{6.408 - 5.894}{\sqrt{\frac{(39)(1.98) + (39)(2.78)}{78}\left(\frac{1}{40} + \frac{1}{40}\right)}}$$

$t = 1.636$

$t^* = 1.994$

$df = n+m-2 = 78$

$P = 0.05$

H_0 is not rejected at .05 level of significance.

BIBLIOGRAPHY

Annand, B. K., Chhinna, G. S., and Singh, "Some Aspects of Electroencephalography in Yogi," Electroencephalograhic and Clinical Neurophysiology, V. 13, p. 452-456, 1961.

Annand, B. K., Chhinna, G. S. and Singh, "Studies on Shri Ramanand Yogi Duringhis Stay in Air-Tight Box," Indian J. Medical Research, V. 49, p. 82-89, 1961.

Anderson, E., "Abnormal Mental States in Survivors With Special Reference to Collective Hallucination," J. Roy, Nav. Med. Serv., Vol. 28, p. 361-367, 1942.

Bagachi, B., Wenger, M., Electro-Physiological Correlates of Some Yogi Exercises," EEG and Clinical Neurophysiology. London: Pergamon Press, 1957.

Bakan, P., "Alpha and Biofeedback Overall View." In Lawrence, J. (ed.), Alpha Brain Wave. New York: Avon Books, p. 15-37, 1972.

Beatty, J., San Diego State University second report, Self-Regulation as an Aid to Human Effectiveness, by W. L. Erickson, 1972.

Benett, A., Sensory Deprivation. Cambridge, Mass.: Harvard University Press, p. 6-33., 1961.

Benson, H. and Wallace, R. K.,"The Physiology of Meditation," Scientific American, 1972.

Berger, G., "Background and History of Biofeedback Techniques and Alpha Brain Wave," in Lawrence, J., (ed.), Alpha Brain Wave. New York: Avon Books, p. 84-103, 1972.

Byrd, R., Alone. New York: G. P. Putnam's Sons, 1938.

Bokert, E., "Alpha Consciousness and the Alpha Experience." In Lawrence, J., (ed.), Alpha Brain Wave. New York: Avon Books, p. 59-83, 1972.

Brenman, M., "The Phenomenon of Hypnosis." In H. Abramson (ed.), Problems of Consciousness. New York: Jonah Macy, Jr., Foundations, p. 123-163, 1950.

Budzinsky, T. and Stovya, J., Biofeedback Technique in Behavior Therapy and Autogenic Training, 1970.

Bundzen, P. V., "Autoregulation of Functional State of the Brain. An Investigation Using Photostimulation with Feedback." Republished: Federation Proceedings translation supplement. Vol. 25, p. 551--54, 1966.

Burney, S., Solitary Confinement. New York: Conard-McCann, 1952..

Bucke, R., Cosmic Consciousness: A Study in the Evolution of the Human Mind. New Hyde Park, N.Y.: University Books, 1961.

Carbone, M. and Honorton, C., "A Preliminary Study of Feedback, Augmented EEG Alpha Activity and ESP Card Guessing Performance." Journal of the American Society for Psychical Research, V. 65, p. 66-74, 1971.

Cavanna, R., (ed.), Psi Favorable States of Consciousness. New York: Garett Publication, 1970.

Coe, G., The Psychology of Religion. Chicago: University of Chicago Press, 1916.

Corso, J. F., The Experimental Psychology of Sensory Behavior. Holt, Rinehard and Winston, Inc., p. 224-227, 1967.

Crider, A., Schwartz, G. E., and Shnidman, S., "In the Criteria for Instrumental Autonomic Conditioning: A Reply to Katkin and Murray." Psychological Bulletin, Vol. 71, p. 455-461, 1969.

Das, J. P., "Yoga and Hypnosis," International Journal of Clinical and Experimental Hypnosis, V. 11, p. 31-37, 1963.

Davidson, R. and Krippner, S., "Biofeedback Research: The Data and Their Implications." In J. Stoyva, T. Barber, L. V. Dicara, J. Kamiya, N. E. Miller, D. Shapiro (eds.), Biofeedback and Self Control. Chicago: Aldine-Altherton, 1971.

Dewan, E. D., Communication by Voluntary Control of the Electroencephalogram. Paper presented at the symposium of Biomedical Engineering, Marquette University, 1966.

Erickson, M. H., A transcript of a trance induction with commentary. In Haley (ed.), Hypnosis and Therapy. New York: Grune and Stratton, 1967.

Feckner, G. T., Etemente der Psychophysik. Leipsiz, Germany: Breitkopf, and Hartel, 1860.

Fehmi, L., "Biofeedback of Electroencephalographic Parameters and Related States of Consciousness." Journal of Motor Behavior, Vol. 1, p. 65-68, 1969.

Fenwick, P. B. C., "The Effects of the Eyes Movement on Alpha Rhythm." Electroencephalography and Clinical Neurophysiology, V. 21, p. 618, 1966.

Fraser, D. C. and Samuel, G. D., "Aircrew Fatigue in Long Range Maritime Reconnaissance: Effects on Vigilance." Air Ministry F. P. R. C. Rep, No. 907.10, 1956.

Gibson, W., The Boat. Boston: Riverside Press, 1953.

Gill, M. and Brenman, M., Hypnosis and Related States: Psychoanalytic Studies in Regression. New York: International University Press, 1959.

Glaser, G. H., EEG and Behavior. New York: Basic Books, 1963.

Green, E. E., Green, A. M., Walters, E. D., and Murphy, G., "Feedback Technique for Deep Relaxation," Psycholphysiology, V. 6, p. 371-377, 1969.

Hart, J. T., Autocontrol of EEG Alpha. Paper presented at the seventh annual report of the Society for Psycholphysiological Research, San Diego, California, October1967, p. 20-22.

Hart, J. T., "Autocontrol of EEG Alpha," J. Psycholphysiology, V. 4, p. 506, 1968.

Hebb, D., "The Motivation Affects of Exteroceptive Simulation," American Psychol., V. 13, p. 109-113, 1958.

Herbart, J. F., Psychologie als Wissenschaft, nen gregrundet auf erfahrung, metaphysik, und mathematik. Konisburg, German: Unzer, 1824.

Heron, W.,"The Pathology of Boredom. Sci. Amer., Vol. 196, p. 52-56, 1957.

Hinkle, L., "The Physiological State of the Interrogation Subject as it Affects Brain Function." In A. Biderman and H. Zimmer (eds.), The Manipulation of Human Behavior. New York: John Wiley and Sons, p. 19-50, 1961.

Hirai, T., "Electro Encephalographic Study on Zen Meditation," Psychiat. Neural Jap, V. 62, p. 76-105, 1960.

Honorton, C., "Relation Between EEG Alpha Activity and ESP Card Guessing Performance," Journal of the American Society for Psychical Research, V. 63, p. 365-374, 1969.

Honorton, C., and Carbone, M., "A Preliminary Study of Feedback, Augmented EEG Alpha Activity and ESP Card Guessing Performance." J. Amer. Society for Psychical Research, V. 65, p. 66-74, 1971.

Honorton, C., Davidson, R. J. and Bindler, P., "Feedback Augmented EEG Alpha, Shifts in Subjective State, and ESP Card Guessing Performance," J. Amer. Society for Psychical Research, V. 65, p. 308-323, 1971.

Kamiya, J., Conditioned Discrimination of the EEG Alpha Rhythm in Humans. Paper presented at the meeting of the Western Psychological Association, San Francisco, April, 1962.

Kamiya, J., "EEG Operant Conditioning and the Study of States of Consciousness." In D. X. Freeman (chm) Laboratory Studies of Altered Psychological States. Symposium of the American Psychological Association, Washington, D. C., September 4, 1967.

Kamiya, J. "Conscious Control of Brain Waves," Psychology Today, Vol. 1, p. 57-60, 1968.

Kamiya, J., "Operant Control of the EEG Alpha Rhythm and Some of its Reported Effects of Consciousness." In C. T. Tart (ed.), Altered States of Consciousness. New York: John Wiley and Sons, 1969.

Kamiya, J., "Biofeedback Research. Data and Implications." In J. Stoyva, T. Barber, L. V. Dicara, J. Kamiya, N. E. Miller, D. Shapiro (eds.), Biofeedback and Self Control. Aldine Altherton, Chicago, p. 3-25, 1971.

Kamatsu, A. and Hirai, T., "An Electroencephalographic Study on Zen Meditation," Folio Psychiat and Neurology Japanica, Vol. 20, p. 315-336, 1966.

Kanellakos, D. P., The Science of the Creative Intelligence, speech delivered at Stanford University in Palo Alto, Calif., in January 1970.

Krippner, S.,"The Hypnotic Trance, the Psychedelic Experience, and the Creative Act," Amer. J. Clin. Hyp., Vol. 7, p. 140-147, 1964.

Krippner, S., "What are Boys and Girls for?," Journal of Learning Disabilities, Vol. 3, p. 45-47, 1970.

Krippner, S., and Davidson, R. J., "Religious Implications of Paranormal Events Occuring During Chemically Induced 'Psychedelic' Experiences." Pastoral Psychology, Vol. 21, p. 27-34, 1970.

Kubie, L., "The Value of Induced Associated States in the Therapeutic Process," Proc. Roy. Soc. Med., V. 38, p. 681-683, 1945.

Labarre, W., They Shall Take Up Serpents. Minneapolis: University Press, 1962.

Linsey, D., "Common Factor in Sensory Deprivation, Sensory Distortion and Sensory Overload." In P. Solomon, et al (eds), Sensory Deprivation. Cambridge, Mass.: Harvard University Press, p. 174-179, 1961.

Lovin, C. and Stanfor, R. G., "Alpha Activity and ESP Performance," Journal of the American Society for Psychical Research, Vol. 64, p. 375-384, 1970.

Ludwig, A. M., "Altered States of Consciousness." In C. T. Tart (ed.), Altered States of Consciousness, New York: John Willey and Sons, p. 9-22, 1967.

Lynch, J. J. and Paskewitz, D. A., "In the Mechanisms of the Feedback Control of Human Brain Wave Activity," Journal of Nervous and Mental Disease, 1971.

Mackworth, N. H., Researches on the Measurement of Human Performance, Med. Res. Council Spec. Rep. No. 268, London, HMSO, 1950.

Magolin, S. and Kubie, L., "The Therapeutic Role of Drugs in the Process of Repression, Dissociation, and Synthetic," Psychosom. Med., Vol. 7, p. 1947-1951, 1945.

Maharishi, M., In the Bhagarad-Gita, England: Penguin Books, 1967.

Marks, R., The Story of Hypnotism. New Jersey: Prentice-Hall 1947.

Mast, T. M. and Heimstra, N. W., "Effects of Fatigue on Vigilance Performance," Journal of Engineering Psychology, V. 3, p. 73-79, 1964.

Montor, K., "Brain Wave Research," Naval Research Review, p. 6-11, April 1973.

Morris, R. L., and Cohen, D., "A Preliminary Experiment on the Relationships Among ESP, Alpha Rhythms and Calling Patterns," Journal of Parapsychology, V. 33, p. 341, 1969.

Moseley, A., "Hypnogotic Hallucinations in Relation to Accidents," abstr., Amer Psychol, 1953.

Mulholland, T., The Concept of Attention and Electroencephalographic Alpha Rhythm. Paper presented at the National Physical Laboratory on "The Concept of Attention in Neurophysiology" Teddington, England, October 1967.

Mulholland, T. and Evans, C. R., "Oculomotor Function and the Alpha-Activation Cycle," Nature, V. 211, p. 1298-1279, 1966.

Murphy, G., Human Potentialities. New York: Basic Books, 1958.

Orne, M. T. and Paskewitz, Visual Effects During Alpha Feedback Training. Paper read at Society for Psychophysiological Research meetins, St. Louis, 1971.

Rapaport, D., "The Autonomy of Ego,"Rull. Menn. Clin., V. 15, p. 113-123, 1951.

Ritter, C., A Woman in the Polar Night. New York: E. P. Dutton, 1954.

Sargant, W., Battle for the Mind. Garden City, N.Y.: Doubleday 1957.

Saul, L. and David, H., "Psychologic Correlation with the Electroencephalogram," Psychosomatic Medecine, V. 11, p. 361, 1949.

Simonov, P. V. and Valueva, M. N., In Physiological Mechanism of Conditioned Switching in Man. EPEBAH, p. 387-400, 1966.

Slocum, J., Sailing Alone Around the World. London: Rupert, Hart-Davis, 1948.

Tart, C. T., Altered States of Consciousness. New York: John Wiley and Sons, Inc., p. 1-8, 1969.

Ullman, M. and Krippner, S., Dream Studies and Telepathy: An Experimental Approach. New York: Parapsychological Foundation, 1970.

Wallace, R. K., "Physiological Effects of Transcendental Meditation," Science, V. 167, p. 1751-1754, 1970.

Welford, A. T., "Fatigue and Monotony." In O. G. Edholm and A. L. Bacharach (eds.), Physiology of Human Survival, New York: Academic Press, p. 433-459, 1965.

Wood, E., Yoga. Baltimore: Penguin Books, 1957.

Woods, J. H., The Yoga System of Patangali. Cambridge: Harvard University Press, 1927.

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